TWO CILIATA OF GREAT SALT LAKE.[1]

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INTRODUCTION.

Great Salt Lake is not a body of water without its natural fauna and flora. Its water has not yet reached the point of saturation for sodium chloride. It is not the lake of no life, whose water is thought, by the public in general, to be purified by the abundance of salt in solution. It is a lake that contains probably less than fifty forms of life, some of which are visible to the naked eye. Upon careful microscopic examination of a generous amount of the Great Salt Lake water (23 per cent. salinity) many forms of life are observed. To date there have been seventeen different forms reported; as nine algæ, five bacteria, two protozoans, one crustacean and two fly larvæ.

The plan of work was to study the effect of dilution on Great Salt Lake forms. Out of a number of algæ and protozoans, two ciliata were chosen for experimentation.

MATERIAL.

The material was collected early in September, 1917, from near the shore of Great Salt Lake in the vicinity of the Salt Air Pavilion and permitted to stand in the laboratory until January, 1918. As no water was added to the material, it concentrated to a density of 1.170 at 60 degrees Fahrenheit, by the first of January, 1918, when the first dilutions were started. A good balance between the animal and plant life was established and the cultures retained their clearness through all the different densities from the point of saturation down to the density 1.015 (at date).[2] The decaying and milky cultures spoken of by other observers were not encountered. The *Aphanothece* and some other plants grew and reproduced, in all the different densities from 1.20 to 1.010, thus serving as animal food and giving the cultures their characteristic lake green color.

[1] Contribution from the Zoölogy Department of the University of Utah.

[2] August 1, 1918.

The number of living organisms appearing was so large in the first cultures, that contamination was suspected. Consequently collections for checking were made April 30, 1918, under all the precautions that one takes in the collection of water samples for bacteriological examination. The material was examined and found to contain the two ciliata described later in this article and some other forms in common with the September material.

Dilution was effected gradually and accurately, by a method of continuous diluting. The process consisted in adding enough distilled water to a culture to lower its density .0025 or one fourth of one per cent. every 24 hours. This method was adopted for several reasons; first, one does not destroy delicate forms that would perish when plunged into water of only one tenth the original density; second, one has before him a continuous picture of the changing life; and third, one deals with the offspring of only a few individuals.

The moist chamber made by the use of the hollow-ground slide was found to be an advantage in the study of these forms. It was made by placing a small quantity of culture, that showed an equal balance between animal and plant life, on a clean cover slip; inverting this over a deep hollow-ground slide, and sealing with vaseline. If small cultures are desired several may be made on one cover slip by means of the platinum loop. In this case a drop of culture is placed in the hollow-ground slide to prevent evaporation. A mechanical stage greatly facilitates the study.

Cultures with a predominance of animals or plants will show the effect of different gases upon the form and habits of both animals and plants. Not only can the effect of gases and liquids on living forms be studied to good advantage, but this preparation makes possible accurate study of responses to light, darkness, heat, etc. Some of these preparations were made fifty days ago and are at date in good condition.

General Discussion.

Diluting the culture medium produced certain definite changes in these two ciliata. These protozoans were found to vary with a change in the supply of food, oxygen, carbon dioxide, and light;

and also with respect to division, conjugation, and encystment. Dilution of the culture medium was accompanied by increased size, increased activity, shortening of the feeling cirri, more active physiological and reproductive processes, and more flexible and contractile bodies.

In changing the density of the culture from 1.110 to 1.040 the Uroleptus packii increased in length from .07 mm. to .11 mm. and the *Prorodon utahensis* increased in length from .06 mm. to .08 mm. The *Uroleptus packii* cysts increased in diameter from .025 mm. to .03 mm., and the *Prorodon utchensis* cysts increased in diameter from .023 mm. to .027 mm. Like changes were also noted among other protozoans.

The protozoans showed an increased activity as the medium became less dense. All estimates of speed were made by means of stopwatch, camera, lucida, and a dial made of concentric rings reading to .01 mm. and .05 mm. The rate given for each protozoan is the average of ten records for each of ten individuals. These rates are given in the following table.

Protozoan.	Date.	Density of Medium.	Distance.	Time.	Kind of Motion.
Uroleptus packii.......	May 20	1.2	100 microns.	10 min.	steady.
"	" 25	1.11	" "	7.5 sec.	"
"	" 25	"	" "	5.6 "	darting.
"	" 25	1.06	" "	3 "	steady.
"	" 29	1.04	" "	2 '	steady.
"	" "	1.06	" "	1–2 "	darting.
Prorodon Utahensis.....	Apr. 29	1.2	100 microns.	20 min.	steady.
"	May 25	1.075	" "	3.5 sec.	"
"	" 25	1.045	" "	3 "	"
"	" 25	1.039	" "	2 "	"

This increased activity was also very interestingly demonstrated by the rate of vibration of the feeling cirri on the *Uroleptus packii*. These ciliates, in the densities below 1.030, moved their feeling cirri hundreds of times faster than the same ciliates moved their feeling cirri when in the saturated densities. At a density of 1.22 one single stroke of the feeling cirrus occupied 15 seconds. One stroke of a feeling cirrus at the density 1.150 occupied 1 second. In the density 1.11 there were at least five strokes per second, while in the densities below 1.030 not even an estimate could be given. The increased activity, that came

with less dense media, was evident in other general movements.

The feeling cirri on the ciliates from the saturated medium were between 17 and 20 microns long, while the feeling cirri on equally large ciliates from a medium with density 1.030 were between 10 and 11 microns long. The two inside feeling cirri of the ciliate in saturated medium were thus reduced by dilution to nearer the length of the two outside ones and the ventral creeping cirri. That is, our ciliate has practically replaced the two specialized feeling cirri by the less specialized cirri.

The physiological and reproductive processes were accomplished in less time in the less dense solutions. With increased dilution; the protozoans ingested more food, the waste vacuole discharged more often, and the contractile vacuole hurried up in a like manner. Reproduction occurred more rapidly and more often as the foregoing processes were speeded up.

The bodies of both protozoans became markedly less rigid as dilution went on. In normal lake water the bodies of both forms were not known to contract any appreciable amount. *Prorodon utahensis* could bend its body through an angle of 30°, while the *Uroleptus packii* was never found in a bent position. At the density of 1.06 the *Prorodon utahensis* was seen to bend through an angle of 180°: or until the anterior part of the body folded on the posterior part. At the density 1.03 the *Uroleptus packii* was seen to bend through an angle of 150°. Both forms in the lower densities could shorten and lengthen the body at will. The *Prorodon utahensis* seemed to have lost all rigidity of body, assuming readily a spherical or a cylindrical form.

These protozoans responded definitely toward light. This fact was demonstrated, first with active and second with encysted forms. The active forms after an exposure to darkness for 12 hours, swam 66 microns in 10 seconds; while after an exposure to darkness for only 6 hours, they swam 100 microns in 10 seconds. The same forms after being exposed to darkness for 12 hours followed by exposure to light for 4 hours swam 300 microns in 10 seconds. These figures show: first, that exposure to darkness was accompanied by decreased activity; second, the longer the exposure to darkness the greater the inactivity; and third, that light was necessary for maximum activity. The

encysted forms for several hours before emerging exhibited periods of rest followed by periods of activity. This could be explained as fatigue. However it was found that they were more active during the day than during the night. It was also noted that individuals quieted down by exposure to darkness were excited to activity in a few minutes by exposure to a 40-watt light (distance 2 feet). These individuals were found to be more active as the intensity of light increased within the limits of photosynthesis. A suggested explanation of these results is found in the fact that the protozoans possess chlorophyll, probably in the form of a symbiotic alga, which gathers carbon dioxide and other wastes from the ciliate, recombines them into food, and liberates oxygen. The utilization of the synthesized food and free oxygen by the protozoan may account for its increased activity.

The geological history tells us that a few hundred thousand years ago Great Salt Lake was a body of fresh water. This suggests that our present salt water forms were in the past fresh water animals. The fact that these forms have withstood the the great change from fresh water to a solution of 23 per cent. salinity shows that they were capable of adaptation. Those forms that were unable to adapt themselves to the salt water have been weeded out and only plastic forms left. The results discussed in the foregoing part of this article show that these ciliata are plastic and capable of great adaptation. They adapted themselves to all densities from 1.22 down to 1.010 (to date), which is almost a complete reversal of a change covering thousands of years.

Description of Species.

Uroleptus packii Calkins[1] (see Fig. 1) is a pale green colored ciliate with dorsal and ventral surfaces, a tapering posterior end, and a blunt anterior end which bears two long and two shorter feeling cirri. This form is .07 mm. long (salinity 23 per cent.). The body is quite rigid; keeping the characteristic shape. The ectoplasm is easily distinguished and carries three marked rows of creeping cirri. These rows of cirri extend diagonally back-

[1] Prof. Gary N. Calkins has seen this form and, provisionally, named it *Uroleptus packii.*

ward from the right anterior end to the left posterior end over the ventral surface. The row fartherest to the left is interrupted one-third of the way back by the peristomial region. This region is bounded on the left by the peristomial membranellas,

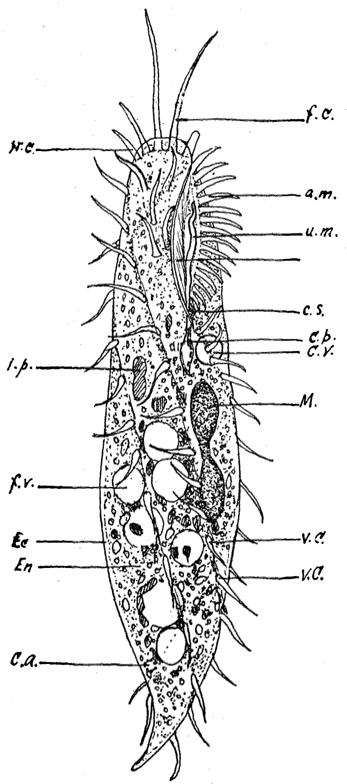

FIG. 1.

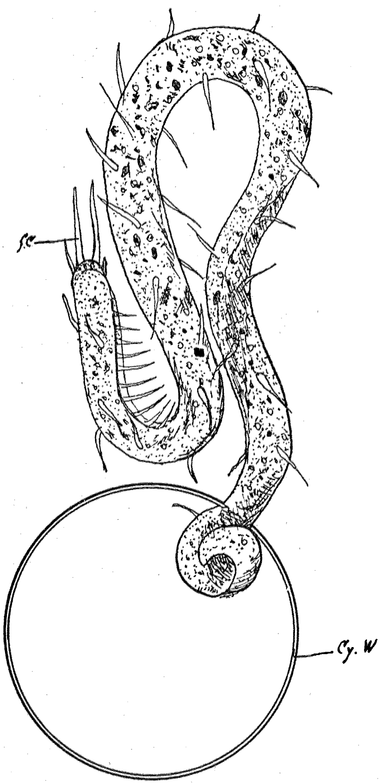

FIG. 2.

FIG. 1. *Uroleptus packii.* *fc*, feeling cirri; *frc*, frontal cirri; *am*, adoral membranellæ; *umt*, undulating membrane (tongue); *um*, undulating membrane; *cs*, cytostome; *cp*, cytopharynx; *cv*, contractile vacuole; *ip*, *Aphanothece* cell; *M*, macronucleus; *fv*, food vacuole; *Ec*, ectoplasm; *En*, endoplasm; *vc*, ventral cirri; *ca*, cytopyge.

FIG. 2. *Uroleptus packii.* *Fc*, feeling cirri; *cyw*, cyst wall.

which extends backward turning slightly to the right, passing through the mouth, and ending in the cytopharynx. The right side of this region is bounded by a large undulating membrane which extends backward and turns slightly to the left. A

second tongue-like undulating membrane extends out of the mouth and forward along the floor of the peristomial region. The cytopharynx is a short swollen tube that extends from the mouth backward with a left dorsal deflection. There may be as many as thirty food vacuoles in the body at one time. The remains of the food vacuoles pass out through the posterior dorsal anus. The contractile vacuole is situated in the fore part of the body. The nucleus is situated midway along the body in the left dorsal quarter. This form derives its color

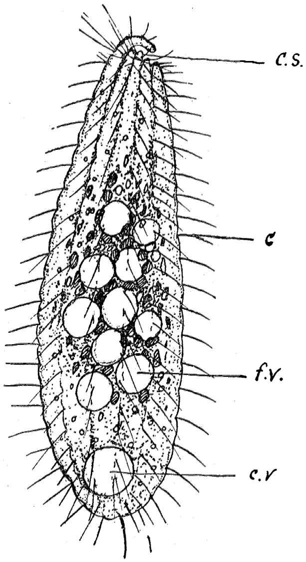

FIG. 3. *Prorodon utahensis.* *cs*, cytostome; *c*, cilium; *fv*, food vacuole; *cv*, contractile vacuole.

from chlorophyll, which is probably in the form of symbiotic alga.

This form takes food in the form of bacteria, small plants and animals which abound in the water. It is a very active form, having a creeping or swimming forward movement of 100 microns per 7 seconds and a darting backward movement of double this speed. This backward movement generally follows irritation at the anterior end. This form when kept in a saturated solution was found to be sensitive to a flash of light from the mirror of the microscope.

Reproduction is brought about by binary fission. Both transverse and longitudinal methods of fission were observed. Conjugation is followed by rapid division. At certain times, perhaps after a full meal, this protozoan encysts and may remain encysted for fifty days. It finally becomes active again and breaks through the cyst wall as a much elongated form (see Fig. 2). After swimming a short time in this form it divides transversely, and if the posterior individual is not sufficiently organized it rounds up into a cyst.

Prorodon utahensis[1] (Fig. 3) is cylindrical in shape, .05 mm. long, and bears an even coat of cilia. The cilia are distributed

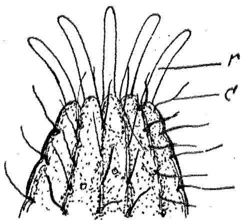

FIG. 4.

FIG. 5.

FIG. 4. *Prorodon utahensis.* Anterior end showing *r*, extended rods.
FIG. 5. *Prorodon utahensis.* Encysted.

between ridges that run parallel to the long axis of the body. These ridges project slightly beyond the opening of the mouth (anterior end) and form finger-like projections. One of which is long and well developed, being used to crowd food into the mouth. The œsophagus is short and fitted with short rods that may be extended in the shape of a star (see Fig. 4). The mouth and œsophagus are capable of being expanded to near the diameter of the body. Food vacuoles are many in number. The contractile vacuole is large and at the posterior end. The nucleus is small. The endoplasm probably contains symbiotic alga.

This form is an active feeder. It lives on bacteria, plant cells, amœbæ, small ciliata, mastigamœba, and other small protozoans found in the lake. An amœba, with a diameter fully equal to

[1] The writer has given the name *Prorodon utahensis* to this form, which is very probably a new species.

that of this ciliate, lost its identity two minutes after being swallowed. At one time an amœba was swallowed that occupied fully one-half of the protozoan's body. It may feed for several hours, then quiet down, contract into a short ellipsoid during which time it extends at intervals the œsophagus rods. After about one hour of this procedure it elongates and swims away, continuing again the process of feeding.

It is an active swimmer. Reproduction is brought about in a short period, by longitudinal fission. Cysts were observed and the contained individuals were found to be sensitive to light, a fact discussed in connection with symbiotic alga.

Conclusions.

1. Though the number of animal and plant species reported from Great Salt Lake is only seventeen, evidence goes to show that this number will at least be doubled.

2. The milky cultures are the result of an unbalanced animal and plant relationship.

3. Continuous dilution was an advantage in that it did not destroy delicate forms, and the offspring of only a few individuals were studied.

4. The two ciliates responded to dilution of the medium by increased size, increased activity, shortening of the feeling cirri, more active physiological and reproductive processes, and more flexible and contractile bodies.

5. These protozoans contain chlorophyll, probably in the form of a symbiotic alga.

6. The results of the foregoing experiments show that these ciliates are plastic and capable of adaptation.

7. It is believed from the foregoing that by slowing down the rate of dilution, some of these Great Salt Lake forms may be transformed into fresh water animals.

8. Most cordial thanks are due Professor Newton Miller, who followed the work with interest and gave many helpful criticisms.

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